Synthese (2024) 203:104
https://doi.org/10.1007/s11229-024-04505-2

ORIGINAL RESEARCH

Processes as variable embodiments

Nicola Guarino[1] · **Giancarlo Guizzardi**[2]

Received: 20 May 2023 / Accepted: 18 January 2024

Abstract
In a number of papers, Kit Fine introduced a theory of embodiment which distinguishes between rigid and variable embodiments, and has been successfully applied to clarify the ontological nature of entities whose parts may or may not vary in time. In particular, he has applied this theory to describe a process such as the erosion of a cliff, which would be a variable embodiment whose manifestations are the different states of erosion of the cliff. We find this theory very powerful, and especially appropriate to capture the intuition that the same process may go on at different times. However, its formal principles have been subject to some criticisms, mainly concerning the mereological structure of a variable embodiment. Moreover, since the notion of variable embodiment is very general, simply saying that processes are variable embodiments is not enough to understand their ontological nature. To address these concerns, in this paper we proceed in two phases: first, we propose a revised version of Fine's original theory adapted to the case of processes, which adopts a classical mereology instead of Fine's hylomorphic mereology, and a temporalized constitution relation in place of Fine's function of variable embodiment; second, we go deeper into the ontological nature of processes by revisiting the notions of homogeneity, intentionality, and telicity discussed in the literature, and propose an account based on ontological principles and not on semantic properties of predicates. This allows us to organize processes into a novel taxonomy based exclusively on their unity and individuation principles.

Keywords Processes · Events · Embodiment · Ontology

✉ Nicola Guarino
nicola.guarino@cnr.it

Giancarlo Guizzardi
g.guizzardi@utwente.nl

1 ISTC-CNR Laboratory for Applied Ontology, Consiglio Nazionale delle Ricerche, Via alla Cascata 56/C, 38123 Trento, Italy

2 Faculty of Electrical Engineering, Mathematics and Computer Science, University of Twente, Zilverling 2007, 7500 AE Enschede, The Netherlands

Published online: 20 March 2024

1 Introduction

In a number of papers, Kit Fine (1982, 1999, 2022) has introduced a theory of embodiment that he has successfully applied to clarify the ontological nature of ordinary objects, acts, ordinary events, and, more recently, activities and processes. He distinguishes between *rigid* and *variable* embodiments. In short, in our understanding, a rigid embodiment is an entity whose parts stand in a relation considered as essential for such entity. The standard example is that of a ham sandwich, whose parts (say, the bread and the ham) stand in a specific relation R, which is considered essential for the sandwich to exist. So, the sandwich *embodies*, in a rigid way, the bread and the ham, and the relation R is called the *principle of rigid embodiment*. Instead, a variable embodiment is an entity whose parts may vary in time. The standard example is that of a car, which keeps its identity despite some of its parts may change (e.g., when a component is replaced). A variable embodiment is an object characterized by a function F from times to things that, for every time, returns the actual sum of parts of that object. This function is called a *principle of variable embodiment*, and in a sense it unifies together the various constituents of an object at different times. Such constituents are called *manifestations* of the variable embodiment.

Fine brings two examples of processes as variable embodiments. In his 1999 paper, he suggested that "a process—such as the erosion of a cliff, for example—may be taken to be a variable embodiment whose manifestations are the different states of erosion of a cliff". In his 2022 paper he focuses on acts, which he sees as rigid embodiments of 'act-neutral' events such as bodily movements or volitions, and he briefly suggests that an activity (such as walking) may be seen as a variable embodiment of acts (such as taking a step). He then generalizes from activities to processes, and from acts to ordinary events,[1] suggesting that a "process or activity" is a variable embodiment of ordinary events.

Under this account of processes, Fine explicitly subscribes (2022, p. 27) to Stout's distinction according to which "an event is something that happens or occurs, while a process is something that is going on or occurring" (Stout, 1997). However, he does not follow Stout's intuition, shared by several philosophers, according to which processes are, in a sense, the matter of events (Crowther, 2011; Galton & Mizoguchi, 2009; Mourelatos, 1978; Stout, 2018b). On the contrary, for him processes are constituted by events, since he considers manifestations of a variable embodiment as constituents of such variable embodiment. In any case, according to Fine's theory, processes and events are disjoint ontological categories.

Of course, there are philosophers who deny the existence of processes in addition to that of events, arguing that the apparent difference between them is just a matter of a different 'viewpoint aspect' (Comrie, 1976), or that they are just 'patterns of occurrence', being therefore types and not tokens (Galton, 2012, 2018). We shall not discuss these positions, but we would like to mention one that is closer to our view:

[1] For Fine (1982, p. 104) ordinary events are rigid embodiments of more basic events: "The events we ordinarily talk about—marriages, battles, epidemies, and what have you are rigid embodiments of a special subclass of events, call them occurrences, at the bottom of other events in much the same way as matter is at the bottom of other material things". In line with this view, acts are for him a subclass of ordinary events that are rigid embodiments of 'act-neutral' events (Fine, 2022, pp. 7–8).

according to Parsons (1990, p. 184) processes are just aggregations of events. Indeed, Parson's position seems very natural, at first sight:

> ...the difference between processes and events is that a process is actually a series or amalgam of events. A walking process is a bunch of overlapping walking events–small ones, large ones, and so on. [...] A running is an event that typically consists of "shorter" events that are also runnings by the same person. If Agatha runs to the store then she may do this by running four blocks along the way; the running-to-the-store is a running, and so is each of the block runnings.

However, as we shall discuss below, the problem with this position is that it cannot explain how *the same* process of running-to-the-store may be ongoing while running each block along the way. In other words, if a process p is identical to a complex event e occurring between t_1 and t_2, resulting from the aggregation of smaller events, how can we say that *the very same process* p is going on at any time during the interval $[t_1, t_2]$, even when e has not occurred yet?

The theory of variable embodiment is an elegant solution to this puzzle, since it explains how a process remains identical to itself while being constituted by different events at different times. Still, there are two problems that, in our view, hinder its concrete application. On the one hand, its formal principles (Fine, 1999) have been subject to some criticism, mainly regarding the mereological structure of a variable embodiment (Koslicki, 2007) and the nature of the function that acts as a principle of variable embodiment (Evnine, 2016). On the other hand, as noticed by several authors (Ferrario et al., 2018; Koslicki, 2007; Moltmann, 2020) the theory is a bit too generous in what objects it allows, as there are no continuity constraints on the manifestations of a single variable embodiment. In particular, saying that processes are variable embodiments is not enough to understand what they are, since a principle of variable embodiment may range on an arbitrary sequence of manifestations, while we need to constrain such range in order to characterize the ontological nature of processes in terms of their unity and individuation principles.

In this paper we shall proceed in two phases, aimed at addressing the two problems above. First, we propose a revised version of Fine's original theory adapted to the case of processes, which adopts classical mereology instead of Fine's hylomorphic mereology, and a temporalized constitution relation in place of Fine's function of variable embodiment. Second, we go deeper into the ontological nature of processes by defining them as variable embodiments of specific kinds, organized along three orthogonal dimensions (homogeneity, intensionality, and telicity) useful for establishing relevant ontological distinctions based on different unity and individuation principles.

Overall, we may consider this paper as an exercise in descriptive ontology,[2] aiming at describing certain aspects of the structure of the world that are apparently presupposed by the different ways we use the words 'process', 'activity', and 'event'. Under this perspective, we believe that any adequate theory of processes should be able to account for:

[2] On the notion of descriptive ontology, see Strawson (1959), and, more recently, Koslicki and Massin (2023). For a radically revisionary approach to the ontology of processes, which denies that the very same process may go on at different times, see Baratella (2023a).

(i) The distinction (if any) between processes and events;
(ii) The relationship between processes and events;
(iii) The criteria for deciding whether the same process is going on at different times;
(iv) The distinction between activities and other processes;
(v) The criteria for interruption, suspension, and completion of a process.

In the following, we shall first discuss issue (i) above to clarify our general position, then we shall introduce our main proposal while discussing issues (ii) and (iii), and finally we shall consider the remaining issues.

2 The distinction between processes and events

Let us start discussing the distinction between processes and events by considering Stout's position, which seems to be subscribed by Fine at least concerning two core assumptions (developed by Stout at different times):

(1) When something is/was/will be happening, it is a process; when something happened/will happen, it is an event (Stout, 1997, p. 19).
(2) Events primarily have their properties atemporally, while processes primarily have their properties at times[3] (Stout, 2016, p. 44)

As Stout clarified, assumption (1) was intended to be merely stipulative, concerning the use of the words 'process' and 'event' as associated, respectively, with the imperfective and with the perfective aspect, leaving open whether this distinction corresponds to different metaphysical categories. Assumption (2), instead, has a clear metaphysical relevance: when we consider the properties of an event (say whether a walk was nice or difficult, how long it lasted, or where it happened), it is not appropriate to ask *when* they were holding. That is, according to this assumption, the properties of events are *timeless*, as they always refer globally to the whole event, not to its temporal parts; as a consequence, events cannot undergo change (at least in the ordinary sense of this term).[4] In contrast, the properties of processes are *temporary*, since we cannot evaluate them unless we specify a certain time. So, a walking process may be fast at a certain time and slow at another time, undergoing therefore a change in the ordinary sense.

Steward (2013, p. 784) objected to (1), arguing that it is natural to assume the following principle:

(3) If a (non-instantaneous) event happened at a certain time, it was happening at a previous time.

[3] Stout clarifies that he uses the adverb 'primarily' since "it is always possible to make atemporal attributions of properties to things that primarily have their properties at a time (and vice versa)", but "such possible attributions are all rather artificial and derivative". On this distinction between processes and events, see also Galton (2008).

[4] As discussed by Baratella (2020), this assumption is denied by those philosophers who subscribe to the perdurantist view, according to which events may change by having different temporal parts exhibiting different properties at different times (Hawley, 2001; Sider, 2001). However, in line with Prior (1962), Hacker (1982), Simons (1987), Galton (2008), we believe that this is not the ordinary notion of change, but rather a notion of temporal variation similar to the spatial variation of physical objects. We discussed the implications of this view in the practice of conceptual modeling in an earlier paper (Guizzardi et al., 2016).

According to this principle, if we assume (1) then all non-instantaneous events turn out to be processeses, demolishing therefore Stout's entire construction. However, in the light of (2) (which was a later clarification by Stout), we can reject (3) since it presupposes a temporal change in the properties of an event (from 'happening' to 'happened'), which is not allowed if we assume that properties of events are timeless.

Anyway, a variant of (3) that perhaps recovers Steward's original intuition makes perfect sense to us, and is not in contrast with (2):

(4) If a process happened at a certain time, it was happening at a previous time.

In other words, we believe that nothing prevents a *process* (not an event) from passing from a time at which it was happening to a time at which it just happened, and indeed it is quite common to say that a process happened (or occurred). This is explicitly denied by Stout (2016, p. 53) who insists that we cannot say that a process happened:

(5) An ongoing process neither is nor ever will be a completed event.[5]

On the other hand, it seems that we keep referring to processes also after they have finished, using the same identifier for the ongoing process and the finished process, so there is no reason to deny that an ongoing process can become a finished (or completed[6]) one. Language therefore seems to contradict Stout's position.

Consider, for example, an airplane flight (say, AZ123 from Munich to Verona on January 1, 2022). The flight took off at time t_1, *it* crossed the Alps between t_2 and t_3, and *it* finally landed in Verona at time t_4. We say that *the same flight* (namely, AZ123) that started at t_1 was going on at t_2 and t_3, and was completed at time t_4. So, what is the denotation of the identifier 'AZ123' in these statements?

A first answer could be that the identifier (joined with a particular day of the year) actually denotes the whole event (i.e, what happened to the plane from take-off to landing). This answer would be however in contradiction with (2), since we are ascribing temporary properties to the flight. Note, moreover, that we may ascribe properties to that flight even before the complete event occurs. For example, at time t_3 the captain might make an announcement like this: "Let me give you some information on *the present flight*. We have just crossed the Alps and we are starting our descent to Verona". Therefore, we have to exclude that the reference of a flight identifier is an event.

Another answer to our question could be that, after all, we are just referring to an object, namely a plane that has been scheduled to take passengers on a particular route. But, besides the fact that the actual plane might be replaced at the last minute (after the boarding phase) while the flight identifier would remain the same, this is not the way we conceptualize this scenario, since we may ascribe to the flight properties that refer to its temporal parts: "The Alps crossing was very calm, but the landing was a bit problematic".

In conclusion, our answer is that this identifier does not denote an event nor an object, but rather a *process* that was ongoing at a certain time and completed at a later time. Stout's answer, instead, would be that this example is a case of product/process

[5] By the way, while the distinction between ongoing and complete processes sounds natural, Stout's expression 'completed event' sounds pleonastic, since for him there is no way an event can be incomplete.

[6] As we shall see, some processes may finish without completing.

ambiguity (Stout, 2018b, p. 212), so that the identifier first denotes a process and then its product (the complete event). In any case, when we refer to something that was ongoing and is now complete, we can only refer to a process, since, strictly speaking, an event cannot be ongoing.[7] Indeed, we may replace Stout's claim (5) with the following:

(6) An event neither is, nor ever was an ongoing process.

In light of this discussion, (1) should be replaced by the following:

(7) Events can only have happened, so they can never be happening. Processes can both (at different times) be happening and have happened.

Note that we do not consider having happened as sufficient for being an event, since also processes may have happened. So, differently from Stout, events and processes are not *defined* in terms of their different linguistic behavior, but, as we shall see, they have their own metaphysical nature.

Besides the revision of his assumption (1), concerning the use of the words 'process' and 'event', a further disagreement with Stout concerns the temporal extension of a process. As we shall see, we defend a view according to which a process has temporal parts, since, at each time it is happening, it is extended in time. Indeed, in many cases, it is natural to describe an ongoing process by mentioning some of its temporal parts. For instance, going back to the flight example, in his announcement at time t_3 the captain would refer to a temporal part of the flight process (the crossing of the Alps) that is no longer present, while the descent to Verona is a new subprocess that is just in the inception stage, whose temporal parts will add to the temporal parts of the flight as long as it goes on. Note that, differently from an event, whose temporal parts are fixed, the temporal parts of a process vary in time, and are therefore *temporary* parts. More exactly, they *accumulate* in time, like the parts of a snowball rolling down a snowy slope, which gradually become inaccessible as they are covered by new parts.

In conclusion, on the one hand we are sympathetic, together with Steward (2015), to Stout's proposal to dub processes as "occurrent continuants", since, like continuants, they primarily have their properties at a time, while, like occurrents, they are entities that happen. On the other hand, we would prefer calling them "continuant occurrents", since they are occurrents that have properties at times, but they are not continuants, since they have temporal parts. In conclusion, our view is that there are two different kinds of occurrents (i.e., entities that happen in time and have temporal parts): processes, which primarily have their properties at a time,[8] and events, which primarily have their properties timelessly. This means that, using Steward's words (2015, p. 122), we "have to accept that some occurrents are capable of change", at least in the sense that they "possess their properties in ways that are not merely atemporal".

[7] The reason is that *to be ongoing* is a temporary property, since we have to specify *when* an event is ongoing. So, assuming that events could be ongoing would violate assumption (2).

[8] More exactly, as Steward (2015, p. 121) underlines, processes "have their properties primarily *between times*, and this implies that they share some of the characteristics continuants are generally thought to have, and some of the characteristics occurrents are generally thought to have".

3 The relationship between processes and events

3.1 Processes as constituted by events

We have seen in the previous section that processes and events are just two different kinds of occurrent. What is the relationship between them? We say that, at each time, a process is *constituted* by a certain series of events, whose nature depends on the process kind. In turn, a process kind is a cognitive construction, which provides the criteria to put together an unfolding series of events that we consider as a growing whole. In a sense, processes are therefore cognitively carved out of events.

In the prototypical case, to say that a process *is ongoing* it is necessary that the initial events of such series have just occurred, while to say that the process is completed the whole series must have occurred. Consider, for example, the process of preparing coffee. We say that such process is ongoing if we observed someone filling the moka with water, putting the filter on, and pouring coffee powder on it. The process is completed after the moka is closed and put on the fire until the coffee comes out.

In a sense, we say that a process is ongoing (or completed) *because* certain events occurred. More exactly, a process is ongoing when events of certain kinds accumulate in a certain way, so we can say that processes are *dynamic accumulations of events*. Moreover, the reason why a process changes is because some event occurs. Consider, for instance, a running process that starts slowly and finally speeds up (Galton & Mizoguchi, 2009): we agree that there is a genuine change in this process, but the reason why it changes is that there is a difference between the events that occur in the early phase of the process and the events that occur in the final phase. This means that we ascribe to events a sort of *ontological primacy* over processes, since processes are *constituted* by events, not vice versa, in contrast to a school of thought (Crowther, 2011, 2018; Galton, 2008; Galton & Mizoguchi, 2009) that claims the opposite, arguing that, in a sense, events are generated by processes.[9] Of course, one may wonder what is the 'power' behind the occurrence of a certain event or the persistence of a certain state (Galton, 2012; Giannini, 2022), but in any case we do not think it is appropriate to call it a process.

A peculiar aspect of our view is that, as long as a process is occurring, its constituting events vary in time. This is the reason why, if suitably adapted and constrained, Fine's theory of variable embodiment seems to be a good starting point for capturing our intuitions.[10] Let us discuss in the following the main choices of our own adaptation of such theory applied to the case of processes.

A first choice has a general nature, and concerns the function that Fine calls the principle of variable embodiment, which in our case is supposed to select, for each time

[9] One may object that whenever there is an event there is also the corresponding process, so there is not really an ontological primacy issue. We shall discuss this objection at the end of this paper, arguing that processes are ultimately cognitive constructions, so that only events have a genuine metaphysical nature.

[10] One of us already adopted Fine's theory of variable embodiments in an earlier paper (Guarino, 2017) focusing on the semantics of occurrent identifiers, but the notion of process introduced there was very different from the one we are presenting here, mainly because there events were understood as being gradually 'filled' by processes, so that the constitution relation was inverted. Moreover, here we do not commit on the existence of future events. See (Galton, 2019) for some valuable criticisms of that approach.

t at which a process is occurring, its corresponding manifestation (i.e., its *constitution*) at t. Instead of associating a function like this with each process, we prefer to introduce a notion of *temporary constitution* (Wasserman, 2021), represented by a primitive predicate $K(x, y, t)$, stating that the process x is constituted by the event y during the atomic interval t.[11] This is clearly just a different representational choice, equivalent to Fine's theory since we assume that K is functional, i.e.,

(A1) $K(x, y, t) \wedge K(x, y', t) \rightarrow y = y'$

The advantage of this choice is that we can easily characterize the general nature of processes and their various subkinds in terms of the rules (expressed by logical axioms) that constrain their constitution relation.[12] We shall assume that K is asymmetric and anti-transitive. The latter choice is a bit non-standard (see however Wilson, 2009), but, just for the sake of simplification, it allows us to ignore issues bound to the presence of multiple levels of constitution (Masolo, 2010). Another constraint typically required for the constitution relation is that constituent and constituted are of different kinds (Baker, 2007, p. 32). This is guaranteed here simply by having processes and events to be disjoint subcategories of occurrents:

(A2) $Process(x) \rightarrow Occurrent(x)$
(A3) $Event(x) \rightarrow Occurrent(x)$
(A4) $\neg\exists x(Process(x) \wedge Event(x))$

A second choice is related to the application of the theory to the case of processes, and concerns the very nature of process manifestations. Regarding this issue, as we have seen, Fine gives two very different examples. In the cliff erosion example (Fine, 1999), the process manifestations are the different states of erosion of the cliff. In the example of a walking activity (Fine, 2022) the manifestations are the single acts of taking a step, which for him are ordinary events (being in turn rigid embodiments of more basic events). Independently of the specific nature of states and events, it seems clear that for Fine a process manifestation is a sort of *snapshot* of something happening at a certain time.

On the contrary, to account for the intuitions concerning the temporal extension of a process discussed above, we shall assume that, when a process is ongoing, its manifestation at a given time is the history of what happened until that time, i.e., the current *life* of the process (Stout, 2003). After a process has ended, its manifestation coincides with its whole life. This corresponds to the following axioms, where t ranges on atomic time intervals, i ranges on arbitrary time intervals, while $Starts$, $Finishes$, $Before$, $Meets$, and $Equals$ are relations taken from Allen's interval logic (1983) generalized to events[13]:

[11] This notion of constitution is similar to the one adopted in the DOLCE ontology (Borgo, Ferrario et al., 2022). Note, however, that the first two arguments are inverted, to stress the comparison with Fine's function of variable embodiment. Moreover, as we shall see, we do not require y to be present during the interval t (Masolo et al., 2003, p. 34).

[12] See Evnine's discussion (2016, pp. 59–65) on the importance of expressing a principle of variable embodiment in terms of rules.

[13] A generalized Allen's relation may have either events or time intervals as arguments, and is logically equivalent to a regular Allen's relation obtained by substituting events with their temporal locations. So, if x is an event and t its temporal location, $Finishes(t', x)$ means that the interval t' is the last part of t.

(A5) $Process(x) \rightarrow \exists yt(K(x, y, t)) \wedge \forall yt(K(x, y, t) \rightarrow Event(y))$
(A6) $Process(x) \wedge K(x, y, t) \rightarrow Finishes(t, y) \vee Meets(y, t) \vee Before(y, t) \vee Equals(y, t)$
(A7) $Process(x) \wedge K(x, y, t) \wedge K(x, y', t') \wedge (Meets(t, t') \vee Before(t, t')) \rightarrow P(y, y') \wedge Starts(y, y')$

Axiom (A5) just says that processes are constituted by events. Axiom (A6) says that the life of a process at a certain time is always finished (in Allen's sense) by that time or occurs before that time, unless the process is just starting, and in that case its life is very short, and is located at t. In practice, this means that, if a process x is constituted by an event y at time t, y must occur *at or before* t, in the sense that it cannot extend after t, but it may have finished before t. Axiom (A7) says that the life of a process accumulates as the process goes on, because the life y of a process x at t must be a starting part of the life y' of the same process at t', if t either meets or is before t'.

To understand how this behavior characterizes processes with respect to objects and events, it may be useful to consider Fig. 1, adapted from (Balashov, 2010, p. 15). The figure refers to the example of a poker (conceived as a unidimensional object), which undergoes a cooling process from midnight to noon. The thick gray arrows denote the relation of exact location. If conceived as enduring (a), at different times the poker is exactly located at 3D slices of its spacetime path. If conceived as perduring (b), it is exactly located at its path. If conceived as exduring (c), at each time there is a poker t-stage that is exactly located at the corresponding t-slice of the poker's path. Finally, (d) shows that the poker's cooling process (represented with dashed boundaries, since it has a variable temporal extension) is exactly located at increasingly large temporal parts of the poker's path as time progresses. We conclude that, like an endurant, a process is multiply located, but it has temporal parts like a perdurant.

3.2 Revisiting Fine's variable embodiment postulates

Having clarified the two main choices behind the view that processes are constituted by events, let us now revisit Fine's variable embodiment postulates (1999, pp. 70–71) adapted to the case of processes, showing how this view differs from Fine's, while still keeping its main intuitions. In their original version, postulates V1–V3 are as follows:

(V1) The variable embodiment $f = /F/$ exists at time t iff it has a manifestation at t.
(V2) If the variable embodiment $f = /F/$ exists at t, then its location is that of its manifestation f_t (assuming that f_t has a location).
(V3) The variable embodiments $/F/$ and $/G/$ are the same iff their principles F and G are the same.

Adapting these postulates to the case of processes is straightforward:

(V1') If p is a process, it exists at time t iff it has a manifestation at t[14].

[14] Note that restricting (V1) to processes, which have to satisfy (A6) and (A7), puts some constraints on the proliferation of variable embodiments that has been criticized in the literature, as noticed in the introduction.

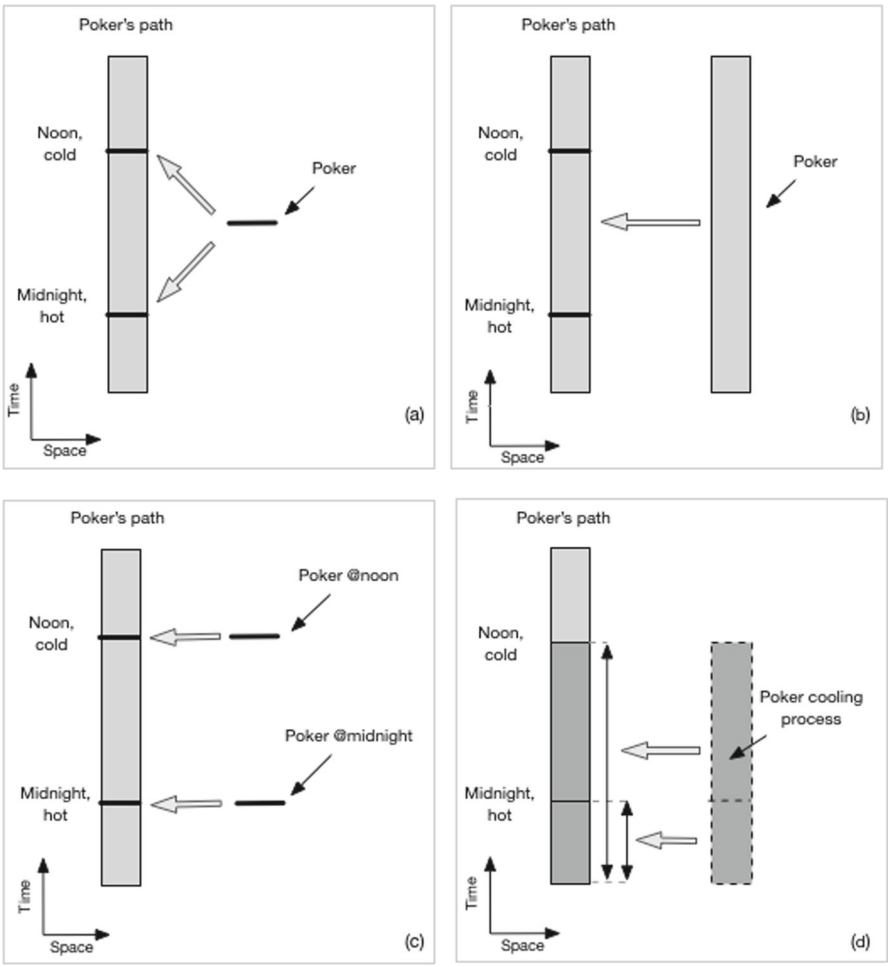

Fig. 1 Different ways of being located in spacetime (adapted from Balashov, 2010)

(V2') If a process p exists at time t, then its temporal location is that of its manifestation.
(V3') The processes p and q are the same iff at each time t their manifestations are the same[15].

Postulate V4 is more problematic. According to Fine, it states a fundamental principle governing how variable embodiments are related to their manifestations:

[15] Since we admit that processes may change, an issue that arises is their cross-world identity. We believe it is plausible to adopt a vision in which, at a certain time, the past is frozen, but the future of a process is open to various possibilities, so that, unlike events, processes are not modally fragile. Such a vision may be described by the so-called *growing block* metaphor (Correia & Rosenkranz, 2018), which however has been introduced in a different context. In any case, we shall ignore modal considerations in the present paper. See (Baratella, 2023b) for a discussion on the modal behavior of processes when understood as variable embodiments under Fine's view.

(V4) Any manifestation of a variable embodiment at a given time is a temporary part of the variable embodiment at that time.

In terms of the constitution relation, this principle would correspond to the following axiom (recall that, for a process, having a manifestation at t means being constituted by a certain event at t):

(V4*) $K(x, y, t) \rightarrow P(y, x, t)$

As Koslicki observed (2007, pp. 147–148), the manifestation y in the formula above should be interpreted as a *proper* temporary part of x at t, since otherwise the variable embodiment x would be *identical* to its manifestation at t, and this would turn numerical identity into a temporalized relation. However, if we accept classical mereology, according to the Weak Supplementation Principle (WSP) we should have *another* proper temporary part of x, disjoint from y. Thus, since the existence of this other part is not guaranteed, Fine's theory of variable embodiment must abandon WSP. Indeed, Fine (2007, pp. 1–2) has objected to WSP on different grounds (bringing counter-examples involving singletons), although he admits that, under a hylomorphic account, WSP might be saved by allowing the formal components of a variable embodiment $x = /F/$ to be proper parts of x in addition to its manifestation. In any case, we do not subscribe to hylomorphism, since we do not believe that the relationship between an object and its form has the same nature as the one between an object and its material parts, and prefer to rely on the solid grounds of Classical Extensional Mereology (CEM).[16] For these reasons, we reject (V4*), following (Baker, 2007) in keeping parthood completely separate from constitution:

(A8) $K(x, y, t) \rightarrow \neg\exists w(P(w, x, t) \wedge P(w, y, t))$

Let us consider now Fine's postulates V5a and V5b, which were originally intended to establish a very general relationship between the parts of a variable embodiment and the parts of its manifestations. Note that the former are *temporary* parts, since the actual parts of a variable embodiment may vary with time, while the latter are *timeless* parts, since they are not related to time:

(V5a) If a is a timeless part of b that exists at t and if b is a part of c at t, then a is a part of c at t.

(V5b) If a is a part of b at t and if b is a timeless part of an object c that exists at t, then a is a part of c at t.

Since, as we have seen, we have decided to keep variable embodiments as mereologically separate from their manifestations, our version of (V5a-b) loses its generality, and only accounts for the parallelism between the temporary mereological structure of a process at t and the timeless mereological structure of the event that is its manifestation at t (see Fig. 2):

(V5a') If a is a timeless part of an event b that occurred at or before t and if b *is a manifestation* of a process c at t, then a *is a manifestation* of a part of c at t.

[16] This choice is also motivated by reasons of compatibility with current top-level ontologies such as DOLCE (Borgo, Ferrario et al., 2022) or UFO (Guizzardi et al., 2022). See (Masolo et al., 2020) for another example of implementing the notion of variable embodiment in terms of constitution plus CEM.

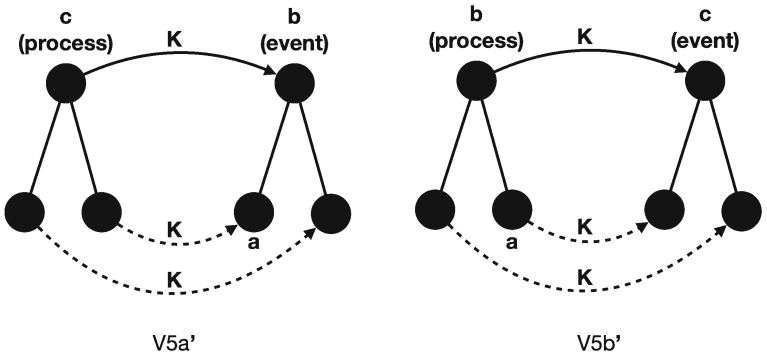

Fig. 2 Fine's principles V5a and V5b revisited. The Hasse diagrams show the mereological parallelism between a process and its constituting event at a time *t*. The dotted links are those inferred from the axioms

(V5b') If *a* is a part of a process *b* at *t* and if *b has as a manifestation* an event *c* that occurred at or before *t*, then *a has as a manifestation* a part of *c* at *t*.

More exactly, (V5a') and (V5b') correspond respectively to the axioms below[17]:

(A9) $K(x, y, t) \wedge P(z, y) \rightarrow \exists w(P(w, x, t) \wedge K(w, z, t))$
(A10) $K(x, y, t) \wedge P(z, x, t) \rightarrow \exists w(P(w, y) \wedge K(z, w, t))$

Consider now Fine's principle V6:

(V6) If *a* is a temporary part of *b* at *t*, then there is a *mereological chain* at *t* connecting *a* to *b*.

For Fine, a mereological chain is a chain of timeless parthood relationships and manifestation relationships. In our case, since we keep variable embodiments as mereologically separate from their manifestations, the only admitted mereological chain is a chain of standard mereological relationships, so that (V6) is a trivial consequence of the fact that parthood is transitive according to CEM.

The final principle of Fine's theory of variable embodiments is principle V7 (Fine, 1999, p. 71)

(V7) The so-called *pro tem* properties of a variable embodiment at a given time (i.e., those that only depend upon how the variable embodiment is at that time) are the same as those of its manifestation at the same time.

To adapt this principle to our case, since the manifestation of a process at time *t* includes the past history of the process as well as what just happened during the atomic time interval *t*, we have to distinguish between *local* and *global* pro-tem properties (Guarino, 2017; Moltmann, 2020).

[17] These two axioms together define an isomorphic mapping between the mereological structure of processes and that of their constituent events. Although the second axiom is uncontroversial, since events can always be decomposed into temporal proper parts, the first axiom may seem too strong. Take, e.g., a strolling process constituted by a sequence of step events. Can we claim that there are subprocesses of strolling that are constitued by each step event, or worse, by each proper part of a step (e.g., lifing one's foot)? Our answer is: yes, but of course these are processes of a different kind, i.e., they are not strolling processes themselves.

The *local* properties of a process are those that, at each time, depend only on what is happening at the process *front*, which is the most recent temporal window of the process life, whose extension depends on the property being considered and on the granularity at which we describe the process. For example, as discussed by Mizoguchi (2009, p. 82), at the granularity of 0.1 s, the speed of a movement process may be defined as the distance covered during the most recent temporal window of 0.1 s, divided by 0.1 s. Formally, for each local temporary property ϕ_L, there exists a temporal part of the process manifestation located at the process front for which a corresponding timeless property ϕ'_L holds, and viceversa:

(A11) $K(x, y, t) \rightarrow \exists y'(P(y', y) \wedge Finishes(y', y) \wedge (\phi_L(x, t) \leftrightarrow \phi'_L(y')))$

On the other hand, the *global* (or *cumulative*) properties are those corresponding to timeless properties of the *whole* process manifestation, which account for the global process history. An example is a property expressing the current score of a football game. Formally, each global temporary property ϕ_G will correspond to a timeless property ϕ'_G holding for the process manifestation at t:

(A12) $K(x, y, t) \rightarrow (\phi_G(x, t) \leftrightarrow \phi'_G(y))$

An implication of (V7) is that processes can genuinely change, admitting different local or global properties at different times. In conclusion, the constitution theory we have introduced so far implements Fine's idea of variable embodiments while sticking to CEM, and adapts it to processes by assuming that their temporal parts accumulate in time.

Let us summarize the discussion so far. While revisiting Fine's theory of variable embodiments applied to the case of processes, we have managed to: (a) propose a revised criterion of identity for processes; (b) characterize their conditions for existence in time; (c) clarify the way they are located in spacetime; (d) show in which sense they can genuinely change; (e) formally characterize the relation between processes and their constituting events, as well as (f) the relation between their respective mereological structures. However, there is a crucial issue Fine has not addressed, which is important to understand the ontological nature of processes: their criteria for unity and individuation, as reflected by their various kinds. This is what we shall discuss in the rest of this paper.

4 Basic distinctions within processes

Besides the problems related to the adoption of an hylomorphic mereology, a further problem of Fine's theory, noticed by several authors (Ferrario et al., 2018; Koslicki, 2007; Moltmann, 2020) is that it is a bit too generous in what objects it allows, since there are no continuity constraints on the manifestations of a single variable embodiment. So, when applied to processes, the theory offers no clues concerning the criteria for deciding whether the same process is going on at different times. This is of course a crucial issue, clearly explained by Stout (1997, p. 21) with the following example:

> Suppose I see a bush fire spreading through one bit of countryside and then some time later see a bush fire spreading through another bit. There is one sense in which it is fairly obvious that what is happening in each case is the same thing-namely a bush fire spreading through the countryside. But there is a further question which we may be interested in, and which is naturally expressed by asking whether it is the very same process of fire spreading which is observed on both occasions.

In formal terms, the issue at hand concerns the *principle of temporal unity* of a process, that is, a principle that tells whether two events occurring in different time intervals are parts of the same process manifestation. A related issue concerns the *principle of temporal individuation*[18], which, given a process manifestation occurring at a certain time, allows us to determine all other manifestations of the same process, that is, its whole life (of course, this is possible only *a posteriori*, after the process is finished). Similar principles are usually adopted for ordinary physical objects for which physical connection counts as a principle of unity, and maximal self-connection counts as a principle of individuation. In general, these principles are conveyed by the linguistic expressions we use to refer to objects, processes, or events.

In this section we shall discuss three dimensions (namely *homogeneity*, *intentionality*, and *telicity*) which have been used in the literature to distinguish between different kinds of process. In the next section we shall see how our revised account of these dimensions, which turn out to be mutually orthogonal, allows us to organize processes into a novel taxonomy based exclusively on their unity and individuation principles.

4.1 Homogeneity

The first dimension that we consider is *homogeneity*. As clarified by Gill (1993, p. 9) two different notions of homogeneity have been used in the literature on events: *semantic homogeneity*, which involves the truth of predications on events, and *empirical homogeneity*, which involves the structural similarity between the various temporal parts of an event. We shall discuss the former notion below in the context of telicity. Here we rather adopt the latter notion, which we prefer to call *structural* homogeneity, and we define it as follows:

(D1) A process is *structurally homogeneous* iff there exists a way of decomposing it in a sequence of subprocesses of the same kind as each other.[19] It is *structurally heterogeneous* (or simply *heterogeneous*) otherwise.

Examples of structurally homogeneous processes are those described by verbal expressions like *running* or *sleeping*. On the contrary, a process described as *preparing a coffee* is structurally heterogeneous. In the following, for the sake of brevity, we shall sometimes just say 'homogeneous' instead of 'structurally homogeneous'.

[18] We have labeled these principles as *temporal* to underline that they have a *diachronic* nature, differently from *spatial* unity/individuation principles that have a *synchronic* nature (Guarino et al., 2022). In the following, we shall omit the 'temporal' adjective for the sake of simplicity.

[19] Note that we do not require *every* subprocess to be of the same kind, allowing for some nonhomogeneity at lower levels of granularity.

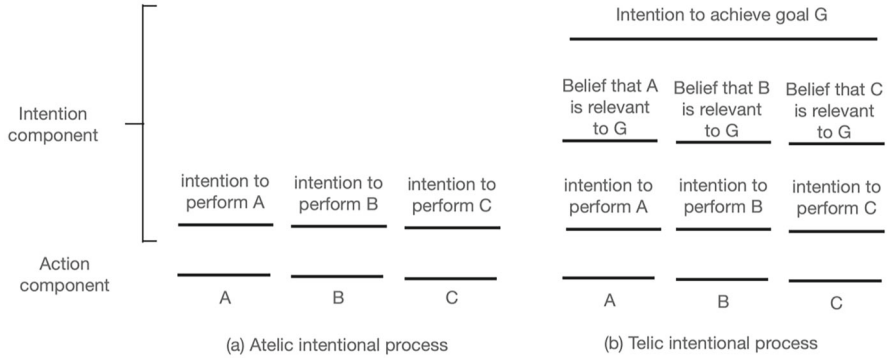

Fig. 3 The synchronic structure of intentional processes

Note that, according to our definition, the kind of the subprocesses may be different from the kind of the main process. Moreover, the definition admits the possibility of sequences of subprocesses of the same kind, but with different participants. So, for example, a conversation process, manifested by a sequence of talking subprocesses involving different participants, will be considered here as structurally homogeneous.

4.2 Intentionality

The second dimension that we shall consider for organizing processes is intentionality. This may be confused with telicity, since prototypical examples of telic processes (such as *going to the station* or *eating an apple*) are also intentional. However, as we shall see, the two dimensions turn out to be orthogonal, at least according to the way we define them. We define intentional processes as follows:

(D2) An *intentional process* is a process whose manifestations are sequences of synchronously complex events each involving two components: (i) an action component, consisting of *acts* (whose nature depends on the process kind) deliberately performed by some agent,[20] and (ii) an intention component, consisting of the mental state(s) of intending to perform those acts, plus possibly other mental attitudes towards those acts (Fig. 3a, b).[21]

So, according to the above definition, manifestations of intentional processes such as *running*, *playing* or *climbing the K2* always include, in addition to their core physical events, also mental events expressing the agent's mental attitude towards such physical events. Note, however, that the action component may not necessarily be physical, allowing the possibility of a purely mental intentional process, such as proving a

[20] Perhaps we should consider also intentional omissions as an example of intentional processes (think of pauses in music, for example). In this case the action component does not exist, and the intention component consists of the mental state of intending to omit certain acts. We leave this issue open in the present work.

[21] The short gaps between A, B and C in Figs. 3a–b and 5a are used here merely as a visual aid to distinguish between these events, not as a indication that there should be a temporal discontinuity between them. The larger gap in Fig. 5b, in contrast, is used there to indicate discontinuity between events A and C.

theorem or mentally preparing a speech. Note also that we admit collective intentional processes by our definition, but we do not discuss their structure here.

4.3 Telicity

The third dimension we shall consider is *telicity*. This notion goes back to Aristotle, and has to do with whether or not an event is described as having an inherent or intended endpoint (also called *telos*). It has been used extensively in linguistics and in philosophy of language to account for relevant distinctions within events, such as those between activities, accomplishments, and achievements (see Casati & Varzi, 2015, for an overview). In particular, much attention has been paid in linguistics to the internal grammatical structure of telic descriptions and to the difference between telicity and boundedness (Declerck, 1979; Depraetere, 1995). Forgetting the internal structure, and considering a whole description as a predicate, the following formal criterion for telicity, introduced by Krifka, is generally accepted nowadays:

(8) Atelic predicates, like *push a cart*, have the subinterval property, that is, whenever they are true at a time interval, then they are true at any part of that interval; this does not hold for telic predicates, like *eat an apple* (Krifka, 1998, p. 197).

However, as Gill (1993) and Krifka himself observed, this is a useful semantic distinction within event *predicates* (that's why atelicity so defined has been labeled by Gill *semantic* homogeneity), but it does not directly correspond to ontological distinctions within individual events:

> It is misleading to think that particular events can be called 'telic' or 'atelic'. For example, one and the same event of running can be described by *running* (i.e., by an atelic predicate) or by *running a mile* (i.e., by a telic, or delimited, predicate). Hence, the distinction between telicity and atelicity should not be in the nature of the object described, but in the description applied to the object (Krifka, 1998, p. 9).

Note that in the above example Krifka describes a run event using the progressive form, stating that the predicate *running a mile* is telic. However, one may argue that, if understood intentionally (i.e., running with the intention of covering a mile), according to Krifka's criterion above the predicate is atelic, since every subinterval of the run is an event in which the agent is running with the intention of covering a mile. We can answer to this objection by observing that, strictly speaking, in linguistics (a)telicity is an aspect category of a *verbal phrase* (VP), not a property of a predicate. In particular, as clarified by Declerck (2007), it is an inherent characteristic of the VP that is *independent* of its grammatical form (say, progressive or non-progressive). So, although the VP of process descriptions typically appears in the progressive form, we must consider their non-progressive form (e.g. *run of one mile* instead of *running a mile*) to use the subinterval property as a test for (a)telicity.

In any case, the telic/atelic distinction adopted in linguistics is a *semantic* distinction that applies to *descriptions* of events, and, indirectly, of their underlying processes. An attempt to provide an *ontological* account of telicity that applies to events has been

made by Higginbotham (2000), who conceives telic events as complex events made up of two parts, represented by the ordered pair $< e_1, e_2 >$, of which the first is the 'processual' part, and the second is the *telos* of the first. This approach however cannot account for *incomplete* telic events, like *John's crossing the street interrupted because he was hit by a car*. Moreover, it is not clear how it could be of help in our treatment of processes as variable embodiments of events: it would be natural to think of telic processes as variable embodiments of telic events, but in Higginbotham's view the 'marker' of a telic event is the telos, which only occurs when the event is completed, so it is not available while the event is ongoing.

From our point of view, we believe it is natural to conceive an *ontological* distinction between telic and atelic processes based on the idea that they are not just *bounded* by an endpoint, but they are finalized to the occurrence of a certain event external to the process itself. Therefore, an atelic process of *running* that stops after a mile or lasts for an hour is still an atelic running, since the endpoints do not affect its nature, while a process of *running to the station* is telic, since its internal structure causally contributes (or is intended to contribute, if the process is intentional) to the occurrence of a culmination event: being at the station.[22]

In light of these considerations, we suggest the following *ontological* definition of telicity for processes[23]:

(D3) A process is *telic* iff its manifestations are sequences of events that causally contribute (or are intended to contribute, if the process is intentional) to the occurrence of a certain culminating event that is *external* to the process, in the sense that it does not involve a global or local property of the process itself.

Note that, if a telic process is intentional, then the culmination event includes the achievement of a *goal*. In this case, the synchronic structure of the process includes the persisting mental state of intending to achieve the goal, and, for each act, the belief that this act contributes to achieving such goal (Fig. 3b).

Note also that (D3) is clearly very different from Krifka's definition (8). Since however, as we have seen, such definition is based on a *semantic* property that does not concern processes, but rather their descriptions, we leave open whether telicity of process descriptions should be redefined in terms of telicity of their processes, or rather maintain the two definitions for reasons of compatibility with the literature mainstream, stressing the difference between the semantic and the ontological level when needed. In the following, we shall adopt the latter option, using (8) for the telicity of VPs, and (D3) for the telicity of processes.

4.4 Telicity and intentionality

To better understand the ontological definition of telicity given above, consider the following sentences, which show the subtle interactions between telicity and intentionality:

[22] Note that we consider states as a subkind of events.

[23] A similar definition may be adopted for telic events, so that telic processes may be seen indeed as constituted by telic events. We do not discuss it here for the sake of simplicity.

9 a. The avalanche is reaching the house.
b. Mary is (deliberately) reaching the house.
c. Mary is (deliberately) running a mile.
d. *Mary is (undeliberately) running a mile.
e. John (who was driving at 80 km/h) is slowing down to 50 km/h to respect the speed limit.
f. ?The car (which was running at 80 km/h) is slowing down to 50 km/h.

The telic VP *reaching the house* may be used to describe an unintentional telic process, as in (9a), or an intentional one, as in (9b). However, the VP *running a mile*, which is also telic, does not behave in the same way, since (9d) is infelicituous. To see this, suppose that a person starts running at time t_1 and is still running at t_2 after a mile has been covered, with no particular intention of stopping after one mile or running for one mile. Clearly we cannot say that, at any time between t_1 and t_2, this person was *running one mile*: she was just *running*. So, *running a mile* can only be interpreted as describing a telic intentional process. What is the reason for this different behavior? We believe that it lies in the different nature of the culmination condition. Indeed, in (9a) the culmination condition is the occurrence of an event *external* to the manifestation of the process (which is a simple moving event): the avalanche gets the house location. In (9b), in addition, another *external* event occurs at the completion time, namely a mental event of goal achievement occurring in Mary's mind. In (9d) the completion condition is expressed in terms of a global property of the process (i.e., the distance covered), so it is *internal* to the process itself, not something external to it. This internal condition cannot be used to describe a process that is ongoing before the condition is satisfied, unless an *external* condition is imposed, as in (9c): in this case, a mental event of goal achievement must occur at completion time. In sentences (9e, f), the culminating condition is instead based on a local property of the process (its speed), and again the only possible interpretation of *slowing down to 50 km/h* is the intentional one.

We conclude from these examples that (i) process descriptions involving internal culminating conditions, such as *running a mile* or *running for an hour*, can only be interpreted intentionally; (ii) not all process descriptions considered as telic according to (8) do actually describe telic processes: we have to verify that the completion condition expressed at the syntactic level corresponds to an event at the ontological level that must be *external* to the process.

The phenomenon we have just described, concerning the role of intentionality in interpreting a process description as telic, has been discussed in some detail by Depraetere (2007). *Contra* (Krifka, 1998) and others, she observed that process descriptions containing a numerical NP, such as *John run one mile* or *John eat three cakes* cannot be interpreted straightforwardly as telic, unless an intentional context is assumed. The test she uses to determine the telicity is, as in our examples, the compatibility with the progressive form: we cannot say that John *is eating* three apples, unless we presuppose an intentional context. Being interested in the pragmatics of discourse, Depraetere tries to explain *why* this happens by proposing a definition of telicity that leverages on the *mutual manifestation* (Sperber and Wilson, 1996) of the described process endpoints among the discourse participants:

A defining criterion for telicity is the presence of an inherent (natural or intended) *mutually manifest* endpoint" (Depraetere, 2007, p. 247, our emphasis).

Unlike our position, intentionality on the side of the process agent is for Depraetere just "one, but not necessarily the only contextual player when it comes to establishing mutually manifest inherent endpoints". In support of this statement, she brings the following examples of process descriptions containing numerical NPs, which clearly seem to have a telic interpretation (being compatible with the progressive form), but are not executed intentionally (Depraetere, 2007, p. 259):

10 a. Unintentionally John is killing five chickens by putting rat poison round the farmyard.
b. (Context: John has begun to clear out the empty boxes in the building.) John is unknowingly driving away three families of pigeons by his spring cleaning.

Depraetere's explanation of these examples is that they are telic because their context is such that the endpoints are mutually manifest. Our position, instead, is that the processes described by these sentences are telic because of their *ontological nature*, independently of the context. Indeed, in (10a) the ongoing process is a poisoning process, which, given the circumstances, will result in the death of the chickens. According to our definition (D3), the process is telic because it causally contributes to the occurrence of the culminating event, which is external to the process itself. Note that in this case the numerical NP (five chickens) does not concern the poisoning process, but something external to it: the process would be the same independently of the number of chickens killed. A similar argument applies to example (10b).

In sum, in our opinion Depraetere's definition of telicity, based on the notion of inherent endpoints, is definitely more adequate than Krifka's criterion, which reduces telicity to semantic nonhomogeneity. However, we believe that our definition is much preferable, since it relies on the ontological properties of processes.

5 Basic kinds of process

Let us now comment on the taxonomy of processes described in Fig. 4. Both homogeneous and heterogeneous processes are divided according to whether they are intentional or unintentional, and in all these cases we can find examples of telic and atelic processes, showing that the three distinctions we have introduced are orthogonal.

5.1 Homogeneous processes

5.1.1 Intentional homogeneous processes

We distinguish two kinds of intentional homogeneous processes: *activities* and *activity accomplishments*. The former are atelic, the latter are telic. Activities are processes whose manifestations are sequences of intentional acts of the same kind, and are described by verbal expressions such as *walking, running, eating apples, etc.*. We consider *static activities* (such as those described by *being seated* or *having fever*) as a limit case of activities. Of course, only static activities are perfectly structurally

- Homogeneous process
  - Intentional
    - Atelic (*activity*)
      John is running, John and Mary are talking
    - Telic *(activity accomplishment)*
      John is running a mile, Bob is eating an apple, Mary is (deliberately) reaching the house
  - Unintentional
    - Atelic
      The temperature is soaring, Mary is blushing
    - Telic
      A leaf is falling down, the avalanche is reaching the house, the glacier is melting
- Heterogeneous process
  - Intentional
    - Atelic
      Bob is playing tennis, Anna is dancing
    - Telic (*process accomplishment*)
      Bob is climbing the K2, John is preparing coffee
  - Unintentional
    - Atelic
      A hurricane is ongoing
    - Telic
      Bob is digesting, a bushfire is ongoing, the wind is cleaning the sky

Fig. 4 Basic kinds of processes

homogeneous, in the sense that *all* their temporal parts are of the same kind, while in general activities are structurally homogeneous modulo a certain granularity. Note that intentional homogeneous processes that involve a variable number of participants are also considered as activities. For example, when we say that there is more talking now than yesterday (Stout, 2018a, p. 12), we may refer to an ongoing *talking* activity that has more participants now than yesterday.

Let us repeat that activities are not events: the same activity may be ongoing for a while, but its manifestations at the times it is ongoing will be different events. Usually, the unity principle of activities is based on a notion of temporal contiguity that plays a role analogous to that played by spatial connection in the case of physical objects: two events belong to the same activity manifestation iff they belong to a sequence of contiguous events of the same kind.[24] However, we also admit the possibility that events belonging to the *action component* of an activity may not be contiguous, as long as, during the interruption interval, the agent still has the intention to continue performing that activity, so that the corresponding mental state, belonging to the *intention component* of the process, is continuous (Fig. 5). We shall say that in this case the two events that occur immediately before and after the interruption are *semi-contiguous*. Consider, for example, a runner that stops momentarily to drink: as long as she intends to keep running, after drinking the same activity continues (note that the drinking event will not be part of the running activity).

Concerning the individuation principle, we shall distinguish between *bona fide* and *fiat* activities. Similar to bona fide physical objects (Smith, 1994), which are

[24] See our previous discussion of the individuation criteria of homogeneous events.

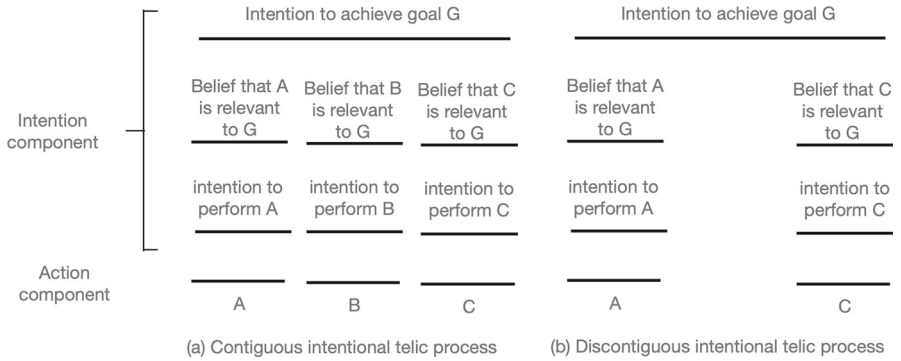

Fig. 5 Contiguous and discontiguous telic intentional processes

maximally self-connected, bona fide activities are processes whose life is a *maximal* sequence of (semi)contiguous events of the same kind invoving the same participant(s). Their temporal boundaries mark therefore a genuine ontological change, since they correspond to the beginning and the end of the activity.[25] On the other hand, fiat activities are proper temporal parts of bona fide activities whose boundaries are just based on formal conditions on their manifestations (such as the temporal or the spatial length), which do not correspond to an ontological change. In the following, we shall refer to bona fide activities simply as activities.

Let us now go back to the case of *running a mile*. As we have seen, this verbal expression can only be interpreted as describing an intentional process. This means that it denotes a process whose manifestations are complex events that include not only a sequence of jumps, but also a persisting mental state of having the intention to accomplish a certain goal, namely running for one mile. This mental state is therefore a (synchronous) proper part of the process manifestation.[26] We call these complex processes *activity accomplishments*. In our case, if the agent stops just after one mile, the process will be just a bona fide activity whose trajectory is one mile long. Its proper temporal parts will be fiat activities like (deliberately) *running the first half mile*, (deliberately) *running the second half mile*, and so on. Of course, there are infinitely many such subprocesses, exactly like there are infinitely many fiat proper parts of a physical object.

5.1.2 Unintentional homogenous processes

Unintentional homogeneous processes are the unintentional counterpart of activities and activity accomplishments. They are very similar to them, but we prefer to reserve the term 'activity' to intentional agentive processes. Examples of atelic processes belonging to this category are those described by expressions such as *the train is moving* or *Mary is blushing*. Telic examples are *a leaf is falling down, the glacier*

[25] Bona fide activities may also be called *activity episodes*.

[26] This means that every intentional telic process includes an atelic process as a proper part, whose manifestation, at each time, is the telic process manifestation minus the agent's intentional state.

is melting, the avalanche is reaching the house. Since in this case we do not have any more the intentional 'glue' that links together the events belonging to the same process manifestation, we adopt for these processes a unity principle based on temporal contiguity.

5.2 Heterogeneous processes

Heterogeneous processes are the paradigmatic case of processes. Their manifestations are sequences of events of different kinds considered as a whole, and not required to be temporally contiguous.

5.2.1 Intentional heterogeneous processes

As described above, intentional heterogeneous processes include the agent's mental state in their manifestation. They may be telic or atelic. A typical example of the former kind is a process of *climbing the K2*. In this case, the completion condition is the achievement of a goal in the agent's mind, and the events that compose each process manifestation are those that are *expected* to contribute to achieving that goal, including unsuccessful attempts. Similarly to the case of activity accomplishments, if the climber stops for a rest, the process continues as long as the intention to achieve the goal is still there.

As examples of atelic intentional heterogeneous processes, we may consider a kid that plays with a ball with no specific goal in mind,[27] or a girl that dances. Differently from the previous case, here the events that compose the process manifestation are not chosen by the agent in order to achieve a specific goal, but simply belong to a predefined pattern.

5.2.2 Unintentional heterogeneous processes

Again, unintentional heterogeneous processes may be telic or atelic. Examples of the former are natural processes such as digesting or burning. For these processes, the 'glue' that links together the events belonging to their manifestations is the causal connection with the completion condition. The unity condition of atelic unintentional heterogeneous processes, instead, is based on the instantiation of a pre-defined occurrence pattern. An example is "a hurricane is ongoing".

Note a radical difference between telic homogeneous processes and telic heterogeneous processes (either intentional or unintentional): While in the former case events of the same kind keep occurring until the completion condition is satisfied, in the latter case the nature of each event depends on the global process state at the time the event occurs.

Finally, let us remark that the taxonomy presented in Fig. 4 is limited to the *basic* process kinds. More complex kinds may be constructed by summing together processes belonging to multiple basic kinds. For example, the Earth's global warming

[27] Notice that *to play* does not denote an event *kind*, since it does not carry specific individuation principles, and it is rather an event *category*. So *playing* does not describe an activity according to our taxonomy, but rather a heterogeneous process.

process may be understood as a sum of homogeneous and heterogeneous processes, both intentional and unintentional. Other examples of complex processes are the so-called *business processes*, which are globally aiming at achieving an organizational goal through the composition of multiple subprocesses of different kinds, typically involving the interaction between machines and intentional agents. We shall not discuss such complex processes here.

5.3 Interruption, suspension and completion

In the Introduction, we stated that an adequate theory of processes should be able to account, among other things, for the criteria for interruption, suspension, and completion of a process. Let us see now how these criteria can be clarified thanks to two notions we have introduced, namely intentionality and telicity. The criteria for interruption apply to all basic kinds of process discussed above, those for suspension apply to all intentional processes (either telic or atelic), and those for completion apply to all telic processes (either intentional or unintentional).

(D4) An atelic process is *interrupted* at a time t simply if it stops at t. A telic process is *interrupted* at t if it stops at t, and the completion condition is not satisfied at t.
(D5) An intentional process performed by a certain agent is *suspended* at time t iff its manifestation has no action component at t, but still the agent has the intention of performing the process, so that only the intention component of the process manifestation is present at t (Fig. 5b).
(D6) A telic process is *complete* at time t if its completion condition occurred at or before t. Otherwise, it is *incomplete* at t.

6 Conclusions

In this paper, we have shown how the notion of variable embodiment can be successfully used to describe and characterize processes, accounting for the five requirements we have listed in the Introduction. We have then explored three orthogonal dimensions (namely homogeneity, intentionality, and telicity) useful to establish relevant ontological distinctions within processes based on their different unity and individuation principles, and proposed a taxonomy based on such distinctions, which in our opinion accounts for most examples discussed in the literature.

For the first task, we made two crucial choices. First, we provided a revisitation of Fine's theory in terms of constitution, abandoning Fine's hylomorphic mereology in favor of classical mereology and relying on a parallelism between processes and events concerning their mereological structure. Second, instead of seeing a process manifestation as a sort of snapshot of something happening at a certain time, we assumed that, when a process is ongoing, its manifestation is the history of the whole process until that time, so that process manifestations accumulate as long as the process goes on.

For the second task, we revisited the notions of homogeneity, intentionality, and telicity discussed in the literature, proposing an account based on the structural properties of process manifestations. In particular, we have proposed a novel definition of homogeneity and telicity based on ontological principles and not on semantic properties, and a characterization of intentional processes based on the synchronic structure of actions and mental attitudes.

Since, in our view, processes are constituted by events, of course we should say something concerning the nature of events. We tried to stay neutral in this respect, sticking to the classic notion of events as perdurants. The only requirement for a theory of events that is compatible with the approach presented here is the capability of distinguishing between co-occurring events and, in particular, distinguishing between an action and the intention to perform that action, which is necessary for us in order to account for the various kinds of intentional process. Therefore, our proposal is compatible with the multiplicativist positions based on Kim (1976) or Lombard (1986), as well as with the view of events as qualitative changes that we have proposed in a recent paper (Guarino et al., 2022).

Finally, as we noticed in Sect. 3.1, the view that processes are constituted by events suggests a sort of primacy of events over processes. We do not want to enter here into deep metaphysical discussions, but we are inclined to think that processes are cognitive constructions, built on top of (ordinary) events similarly[28] to the way that, for Fine (1982), ordinary events are built on top of basic events. These constructions are motivated by our cognitive needs, and are the result of employing the principles of individuation and unity provided by the *kinds* that populate one's ontology.

This means that we do not claim that for any event there is a corresponding process whose life is the event itself.[29] A process exists only as an instance of the corresponding kind, motivated by cognitive needs. For example, we construct the process of *walking to the station* because we find it useful to use a single identifier (*that* walk) to refer to something that was *ongoing* at a certain time and completed at a later time; otherwise, to refer just to the completed entity, the category of ordinary events would suffice. What makes such an ongoing entity different from its manifestation is the possibility that there will be new future events accumulating as temporal parts of a new manifestation, that is, that *the same* entity will remain ongoing. In conclusion, like an historian reconstructs processes by looking at past events, individuating and distinguishing them according to certain perspectives, so we adopt a similar approach in our everyday talk, creating process kinds that reflect unity and individuation principles based on our cognitive needs.

Acknowledgements We are grateful to Riccardo Baratella, Antony Galton, and Pierdaniele Giaretta for their valuable comments on the previous versions of this work.

Funding Open access funding provided by Consiglio Nazionale Delle Ricerche (CNR) within the CRUI-CARE Agreement.

[28] Although with some differences, as now should be clear.

[29] In particular, there is no process that results in an atomic event, since there are no shorter events that would constitute such process. On the other hand, it is certainly possible for an atomic event to be the constituent of a process that is just beginning.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

References

Allen, J. F. (1983). Maintaining knowledge about temporal intervals. *Communications of the ACM, 26*(11), 832–843.

Baker, L. R. (2007). *The metaphysics of everyday life: An essay in practical realism*. Cambridge University Press.

Balashov, Y. (2010). *Persistence and spacetime*. Oxford University Press.

Baratella, R. (2020). Are there occurrent continuants? A reply to Stout's 'The category of occurrent continuants'. *Dialectica, 74*(3), 509–519.

Baratella, R. (2023). Processes and events as rigid embodiments. *Synthese, 202*(181).

Baratella, R. (2023). Processes and their modal profile. *Synthese, 201*(3), 1–24.

Borgo, S., Ferrario, R., Gangemi, A., Guarino, N., Masolo, C., Porello, D., Sanfilippo, E. M., & Vieu, L. (2022). DOLCE: A descriptive ontology for linguistic and cognitive engineering. *Applied Ontology, 17*(1), 45–69.

Casati, R., & Varzi, A. (2015). Events. In E. N. Zalta (Ed.), *The Stanford encyclopedia of philosophy.* Metaphysics Research Lab, Stanford University.

Comrie, B. (1976). *Aspect. An introduction to the study of verbal aspect and related problems*. Cambridge University Press.

Correia, F., & Rosenkranz, S. (2018). *Nothing to come: A defence of the growing block theory of time, volume 395 of synthese library*. Springer.

Crowther, T. (2011). The matter of events. *The Review of Metaphysics, 65*(1), 3–39.

Crowther, T. (2018). *Process as continuants and processes as stuff, process, action, and experience* (pp. 58–81). Oxford University Press.

Declerck, R. (1979). Aspect and the bounded/unbounded (telic/atelic) distinction. *Linguistics, 17*(9–10), 761–794.

Declerck, R. (2007). Distinguishing between the aspectual categories '(a)telic', '(im)perfective' and '(non)bounded'. *Kansas Working Papers in Linguistics, 29*, 48–64.

Depraetere, I. (1995). On the necessity of distinguishing between (un)boundedness and (a)telicity. *Linguistics and Philosophy, 18*, 1–19.

Depraetere, I. (2007). (a)telicity and intentionality. *Linguistics, 45*(2), 243–269.

Evnine, S. J. (2016). *Making objects and events: A hylomorphic theory of artifacts, actions, and organisms*. Oxford University Press.

Ferrario, R., Masolo, C., & Porello, D. (2018). *Organisations and variable embodiments.* In Formal ontology and information systems (FOIS 2018) (pp. 127–140). IOS Press.

Fine, K. (1982). *Acts, events and things.* In Sixth International Wittgenstein Symposium, Kirchberg-Wechsel (Austria) (pp. 97–105).

Fine, K. (1999). Things and their parts. *Midwest Studies in Philosophy, 23*(1), 61–74.

Fine, K. (2007). Response to Kathrin Koslicki. *Dialectica, 61*(1), 161–166.

Fine, K. (2022). Acts and embodiment. *Metaphysics, 5*(1), 14–28.

Galton, A. (2008). Experience and history: Processes and their relation to events. *Journal of Logic and Computation, 18*(3), 323–340.

Galton, A. (2012). *States, processes and events, and the ontology of causal relations.* In Formal Ontology in Information Systems (FOIS 2012), IOS Press (pp. 279–292).
Galton, A. (2018). Processes as patterns of occurrence. In R. Stout (Ed.), *Process, action, and experience* (pp. 41–57). Oxford University Press.
Galton, A. (2019). Guarino's possibilism. In S. Borgo, R. Ferrario, C. Masolo, & L. Vieu (Eds.), *Ontology makes sense: Essays in honor of Nicola Guarino.* IOS Press.
Galton, A., & Mizoguchi, R. (2009). The water falls but the waterfall does not fall: New perspectives on objects, processes and events. *Applied Ontology, 4*(2), 71–107.
Giannini, G. (2022). Powers, processes, and time. *Erkenntnis, 87*, 2801–2825.
Gill, K. (1993). On the metaphysical distinction between processes and events. *Canadian Journal of Philosophy, 23*(3), 365–384.
Guarino, N. (2017). *On the semantics of ongoing and future occurrence identifiers.* In Int. Conf. on Conceptual Modeling (ER 2017), (pp. 477–490). Springer.
Guarino, N., Baratella, R., & Guizzardi, G. (2022). Events, their names, and their synchronic structure. *Applied Ontology, 17*(2), 249–283.
Guizzardi, G., Botti Benevides, A., Fonseca, C. M., Porello, D., Almeida, J. P. A., & Prince Sales, T. (2022). UFO: Unified foundational ontology. *Applied Ontology, 17*(1), 167–210.
Guizzardi, G., Guarino, N., & Almeida, J. P. A. (2016). *Ontological considerations about the representation of events and endurants in business models.* In Int. Conf. on Business Process Management, (pp. 20–36). Springer.
Hacker, P. M. S. (1982). Events and objects in space and time. *Mind, 91*(361), 1–19.
Hawley, K. (2001). *How things persist*. Oxford University Press.
Higginbotham, J. (2000). On events in linguistic semantics. In J. Higginbotham, F. Pianesi, & A. Varzi (Eds.), *Speaking of events* (pp. 49–80). Oxford University Press.
Kim, J. (1976). *Events as property exemplifications.* In Action theory. Proceedings of the Winnipeg Conference on Human Action, Winnipeg, Manitoba, Canada, 9–11 May 1975 (pp. 159–177). Springer.
Koslicki, K. (2007). Towards a neo-Aristotelian mereology. *Dialectica, 61*(1), 127–159.
Koslicki, K., & Massin, O. (2023). A plea for descriptive social ontology. *Synthese, 202*(60).
Krifka, M. (1998). The origins of telicity. In S. Rothstein (Ed.), *Events and grammar, studies in linguistics and philosophy* (pp. 197–235). Springer.
Lombard, L. B. (1986). *Events: A metaphysical study*. Routledge.
Masolo, C. (2010). Understanding ontological levels. In KR '10: Proceedings of the Twelfth International Conference on Principles of Knowledge Representation and Reasoning, (pp. 1258–1268).
Masolo, C., Borgo, S., Gangemi, A., Guarino, N., & Oltramari, A. (2003). *WonderWeb Deliverable D18: Ontology Library (including the DOLCE ontology)*. ISTC-CNR: Technical report.
Masolo, C., Vieu, L., Ferrario, R., Borgo, S., & Porello, D. (2020). Pluralities, collectives, and composites, In Formal Ontology in Information Systems, Proceedings of the 11th International Conference (FOIS 2020), eds. Brodaric, B. and F. Neuhaus, Frontiers in artificial intelligence and applications, (pp. 186–200). IOS Press.
Moltmann, F. (2020). Variable objects and truth-making. In M. Dumitru (Ed.), *Metaphysics, meaning, and modality. Themes from Kit Fine.* Oxford University Press.
Mourelatos, A. P. (1978). Events, processes, and states. *Linguistics and Philosophy, 2*(3), 415–434.
Parsons, T. (1990). *Events in the semantics of English* (Vol. 5). MIT Press.
Prior, A. N. (1962). *Changes in events and changes in things*. Department of Philosophy: University of Kansas.
Sider, T. (2001). *Four-dimensionalism: An ontology of persistence and time*. Oxford University Press.
Simons, P. (1987). *Parts: A study in ontology*. Oxford University Press.
Smith, B. (1994). Fiat objects. In N. Guarino, L. Vieu, and S. Pribbenow (Eds.), Parts and Wholes: Conceptual Part-Whole Relations and Formal Mereology, 11th European Conference on Artificial Intelligence, Amsterdam, 8 August 1994.
Sperber, D., & Wilson, D. (1996). *Relevance: Communication and cognition*. Wiley-Blackwell.
Steward, H. (2013). Processes, continuants, and individuals. *Mind, 122*(487), 781–812.
Steward, H. (2015). What is a continuant? *Aristotelian Society Supplementary, 89*(1), 109–123.
Stout, R. (1997). Philosophy. *Processes, 72*(279), 19–27.
Stout, R. (2003). The life of a process. In G. Debrock (Ed.), *Pragmatic process: Essays on a quiet philosophical revolution.* Brill.
Stout, R. (2016). The category of occurrent continuants. *Mind, 125*(497), 41–62.

Stout, R. (2018). *Introduction to "Process, action, and experience"* (pp. 1–19). Oxford University Press.
Stout, R. (Ed.). (2018). *Process, action, and experience.* Oxford University Press.
Strawson, P. F. (1959). *Individuals*. Routledge.
Wasserman, R. (2021). Material constitution. In E. Zalta (Ed.), *Stanford Encyclopedia of philosophy.* Stanford University.
Wilson, R. A. (2009). The transitivity of material constitution. *Noûs, 43*(2), 363–377.